



Snowmass 2020 Community Planning Meeting

Bo Jayatilaka, Brendan Kiburg

PAC Meeting

December 9th, 2020

PAC Charge

- We ask the committee to review the contributions made by Fermilab staff at the CPM, and to assess their impact and breadth.

Outline

- CPM organization and context in Snowmass process
- Fermilab participation in CPM (Meeting + LOIs)
- CPM by the numbers
- Fermilab Themes
- Path Forward

CPM Organization and Context in Snowmass Process

- In 2019, Fermilab proposed to offer to facilitate the kickoff meeting in Fall 2020
 - This was encouraged by the PAC
- The Fermilab Scientist Advisory Council and User's Executive Committee extended the offer to the Snowmass Steering Committee in early 2020
- In early March 2020, our offer was accepted and we agreed to have a 2.5 day meeting
- We promptly moved into the work-from-home mode
- In July 2020, the decision was finalized to virtualize the meeting, to take place October 5th-8th
 - The meeting duration was extended to 4 half-days, respecting zoom fatigue
 - The meeting times were established from 11am - 4pm central such that the meeting occurred during the traditional workday for all continental US time zones

CPM Organization

Organizing Committees

Program Committee

- *Snowmass Steering Group*: Young-Kee Kim, Tao Han, Joel Butler, Prisca Cushman, Sergei Nagaitsev, Yury Kolomensky, Glennys Farrar, Gabriela Gonzales
- *Frontier Conveners*: Laura Reina (EF), Patrick Huber (NF), Marina Artuso (RF), Aaron Chou (CF), Aida El-Khadra (TF), Tor Raubenheimer (AF), Jinlong Zhang (IF), Oliver Gutsche (CompF), John Orrell (UF), Breese Quinn (CommF)
- *Early Careers*: Vishvas Pandey (postdoc), Joshua Barrow (graduate student)
- *Local Organizing Committee* (Ex-officio Members): Bo Jayatilaka, Brendan Kiburg

Local Organizing Committee

- Jonathan Asaadi, Saptaparna Bhattacharya, Zoltan Gecse, Shih-Chieh Hsu, Bo Jayatilaka (co-chair), Brendan Kiburg (co-chair), Erica Snider, Tiziana Spina, Gordon Watts, Yuanyuan Zhang

- The scientific program was developed by the Program Committee which tried to balance competing interests, and was advised by steering group
- The LOC implemented the meeting logistics
 - Learned from hosting Neutrino 2020 and Users' Meeting virtually
 - Overlap with LOC for those two meetings, as well as CSS 2021

The Organizers established some goals for the meeting

- The primary goal of the Community Planning Meeting is **to develop plans and steps to take (“Snowmass Planning”) between October 2020 and the Snowmass Community meeting in July 2021, leading to a final report in October 2021.**
- Other goals include:
 - Inspire the community about the field, and encourage them to engage broadly in the Snowmass process
 - Inform the community about plans from other regions and from related fields and planned Snowmass activities
 - Listen to the community
 - **Provide space for members across the field to talk to each other and to discuss, promote, and develop new ideas**
 - **Establish cross working-group connections and identify gaps**

CPM Organization and Context in Snowmass Process

- Meeting content
 - From April to October 2020, various frontiers began hosting single-day workshops to begin organizing for the 2021 CSS (10 frontier and 80 topical group workshops)
 - *Letters of Interest the main mechanism for getting on the Snowmass roadmap* and were due to frontier organizers on Aug 31st, 2020, 5 weeks before the meeting
- Some unique capabilities of CPM
 - Due to proximity to LOI deadline, the CPM provided a first opportunity to get a global snapshot of the topics that are currently being pursued by our community
 - Because of the size of the meeting, allowed cross-frontier communication that is missing from the single-day workshops
 - Topical Conveners proposed topics → harmonized by Frontier Conveners
- Implications
 - Several frontiers (e.g. Energy, Neutrino) really focused on cross-frontier studies, since their frontier-specific workshops could occur separately
 - Other frontiers (e.g. Accelerator, Cosmic) chose to kick off quite detailed programs
 - Different choices reflect different optimizations between planning and completeness

CPM Structure

- Day 1:
 - Started with input from other regions and agencies
 - Snapshot of LOIs at a 3MT Town Hall session
- Day 2-3
 - Focused on breakouts for individual frontiers and cross-frontier planning
- Day 4
 - Accelerator directors panel
 - Frontier summaries

Time (US Central)	Oct 5 (Mon)	Oct 6 (Tue)	Oct 7 (Wed)	Oct 8 (Thu)
9:00 AM				Plenary Future Global Accelerator Facility Panel Discussion <i>Zoom Webinar</i>
10:00 AM				
11:00 AM		Frontier Intros <i>Zoom Rooms</i> <i>(see schedule for details)</i>	Plenary Community Engagement <i>Zoom Webinar</i>	Plenary • Early Careers Report • Frontier Summary Reports • Closing <i>Zoom Webinar</i>
12:00 PM	Plenary • Introduction • Strategies and Plans from Other Regions • Strategies and Plans from Other Fields • Remarks from Funding Agencies <i>Zoom Webinar</i>	Breakouts <i>Zoom Rooms</i> <i>(see schedule for details)</i>		
1:00 PM			Breakouts <i>Zoom Rooms</i> <i>(see schedule for details)</i>	
2:00 PM				
3:00 PM	Plenary Voices from the Community Town Hall <i>Zoom Webinar</i>		Frontier Planning <i>Zoom Rooms</i> <i>(see schedule for details)</i>	
4:00 PM				

CPM Structure

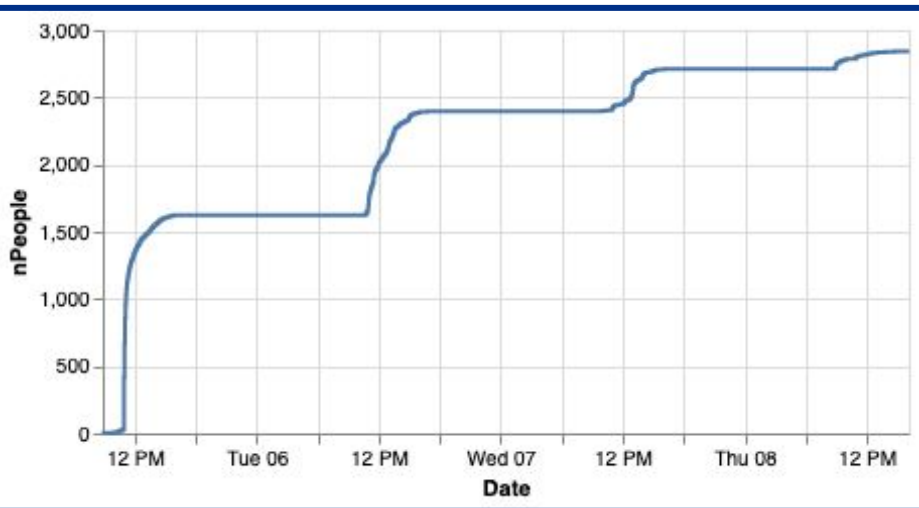
- Opened with planning intros for each frontier
- Most of the day had 21 parallel Zoom sessions
- To facilitate discussion, most Zoom rooms were held open between sessions
- Shorter session Wednesday, including planning session for each frontier

zgcse.web.cern.ch/zgcse/SessionTimeline.html																																		
		Monday 05/10										Tuesday 06/10		Wednesday 07/10		Thursday 08/10																		
Time: (CDT)		11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00												
Join Webinar																																		
Join Zoom 1	1. EF Intro (#cpm_ef_intro)	129. Higgs Factories							Zoom 1 Break and Chat					127. Searches for dark sectors																				
Join Zoom 2	2. NF Intro	109. Determining the Masses and Nature of Neutrinos							Zoom 2 Break and Chat					71. Instrumentation for Break and Chat Future radio intensity mapping surveys					97. Neutrinos as Probes of Standard and BSM Particle Physics															
Join Zoom 3	3. CF Intro	77. Quantum Sensors for Wave and Particle Detection					Break and Chat			102. The Roles of QIS in HEP					Break and Chat					Zoom 3 Break														
Join Zoom 4	4. AF Intro	Zoom 4 Break and Chat							126. BSM: direct and indirect searches							Break and Chat					101. Higgs as a probe of new physics													
Join Zoom 5	5. RF Intro	108. Accelerator Probes of Light Dark Matter (keV-GeV)					Zoom 5 Break and Chat			108. Accelerator Probes of Light Dark Matter (keV-GeV)					Zoom 5 Break and Chat					Break and Chat					29. Low-energy precision experiments									
Join Zoom 6	6. TF Intro	125. EFTs for new physics sensitivity studies							Zoom 6 Break			128. From Amplitudes to Precision Theory for Future Colliders										Zoom 6 Break		141. Gravitational wave source modelling										
Join Zoom 7	7. UF Intro	Zoom 7 Break and Chat							122. Capabilities needed to execute underground experiments in a broad range of research categories							Break and Chat					Zoom 7 Break													
Join Zoom 8	8. CEF Intro: CEF Introduction	Zoom 8 Break and Chat							118. Cross-community Mobility in Science							Zoom 8 Break and Chat					Break and Chat					Zoom 8 Break								
Join Zoom 9	9. IF Intro and LOIs						Zoom 9 Break and Chat			69. Instrumentation for 54. Machine Detector Interface for Future Future Optical Surveys Colliders - #cpm_topic_69										Break and Chat					51. Requirements for low background and underground detectors									
Join Zoom 10	10. CompF Intro and LOIs						Zoom 10 Break and Chat			81. Computing Requirements/Opportunities NF										Break and Chat					123. Data Handling and AI/ML									
Join Zoom 11		92. Non-perturbative QCD dynamics at colliders							Zoom 11 Break and Chat			124. Lattice Gauge Theory for High Energy Physics										Break and Chat					40. Exotic Hadron Spectroscopy and Interpretation							
Join Zoom 12		130. Enabling technologies for low mass and ps timing detectors							131. Physics requirements for HEP colliders			Break and Chat			70. Instrumentation for Break and Chat Future sub-mm Surveys					64. Computing Needs of the Accelerator Frontier														
Join Zoom 13		136. Heavier particle dark matter $\gg 10$ GeV					Zoom 13 Break and Chat			74. Atomic to Cosmic: Wave Dark Matter and Beyond										Break and Chat														
Join Zoom 14		72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72					139. Testing LambdaCDM cosmology at low and			Zoom 14 Break and Chat			140. Future medium to ultrahigh energy gamma-ray detectors - #cpm_session_140					Break and Chat																
Join Zoom 15		Zoom 15 Break							149. Organizing the Early Universe: origins, relics, and BSM					68. Computing in Cosmic Frontier Surveys			142. Analysis/theory techniques for joint cosmological constraints					143. Simulations for joint cosmological constraints												
Join Zoom 16		Zoom 16 Break							146. Small Projects to Enhance Stage IV photometric surveys					147. Novel Ideas in Astronomical Observations			Break and Chat			132. Collider Data Analysis Strategies														
Join Zoom 17		145. QCD phase transitions and ultra-high density matter: Zoom 18 Break					Zoom 17 Break and Chat													80. Computing Requirements & Opportunities for the Energy Frontier					Zoom 17 Break and Chat									
Join Zoom 18												61. Energy and Power and Time structure goals for Neutrino Frontier programs										Zoom 18 Break and Chat												
Join Zoom 19		171. AF2 organization with contributors					Zoom 19 Break and Chat			172. Near-term applications of plasma accelerators					173. AF3 organization with contributors					Zoom 19 Break and Chat					174. Cancelled: AF1 organization with contributors									
Join Zoom 20		175. Accelerator research centers and test facilities for future accelerators					Zoom 20 Break and Chat			176. Grand challenges of ultimate beams and ultimate high energy colliders: Grand challenges of ultimate beams and ultimate high energy colliders										Zoom 20 Break and Chat					177. AF7_rf organization with contributors					178. Common accelerator goals/technology at the				
Join Zoom 21		179. AF7_Targets and Sources organization with contributors					Zoom 21 Break and Chat			180. SRF and magnets for Higgs factories					181. Merged with Session 173 in Zoom 19			182. Energy and power limits for plasma accelerators					Zoom 21 Break and Chat					183. Intermediate lepton collision energies between 500 GeV and 3 TeV						

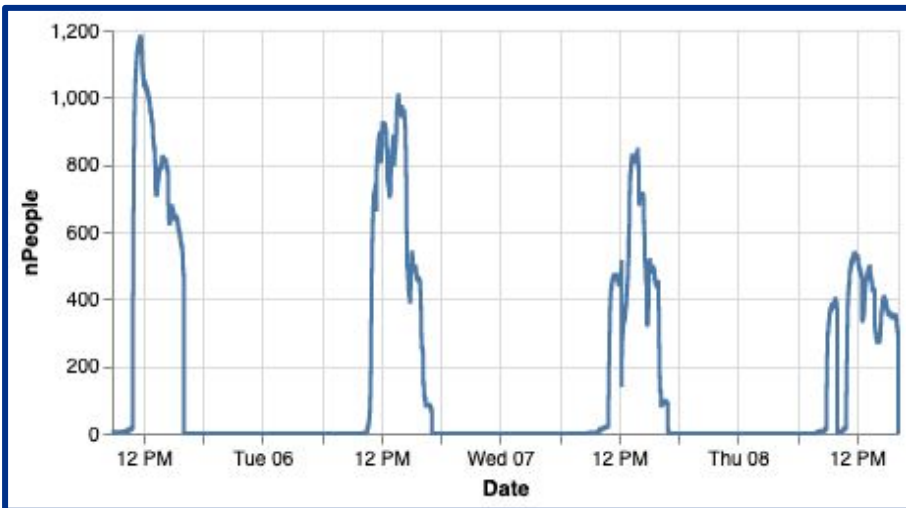
Participation in the CPM

- 3028 Registrants, over 90% logged into part of the meeting
- 275 Fermilab Registrants
- 100 Parallel Sessions

Integrated Unique Participants Vs Time



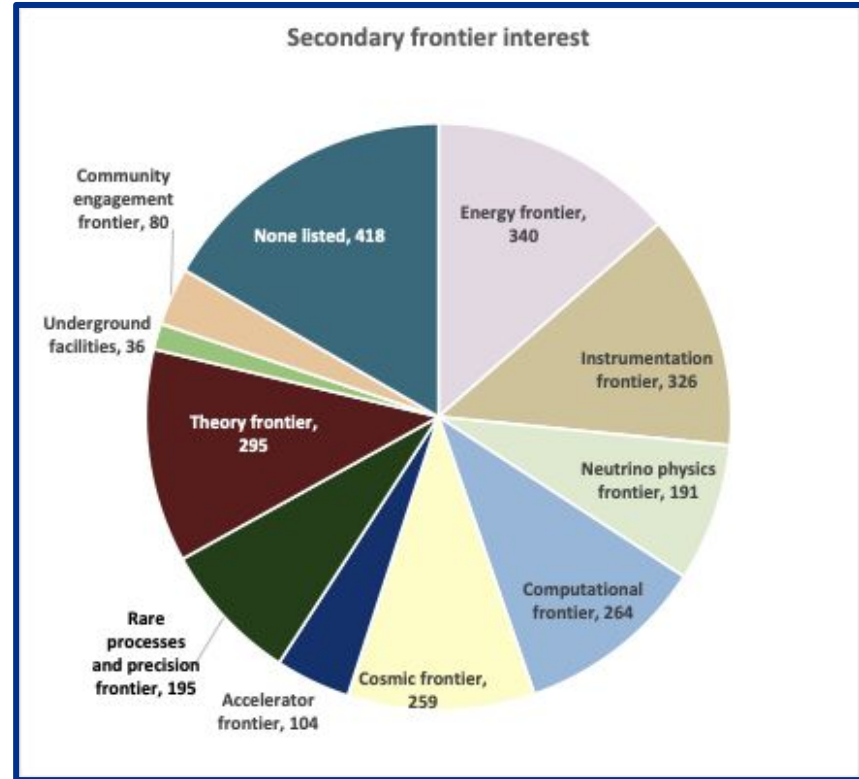
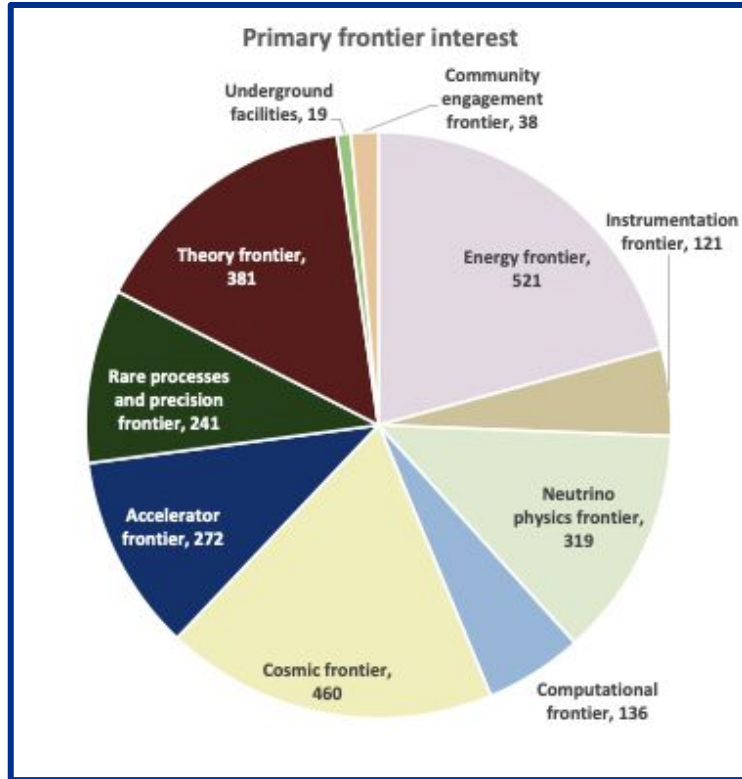
Unique Participants At Any Time



Plots from <https://gordonwatts.github.io/snowmass-cpm-attendance/>

Frontier Participation (all registrants)

Surveyed Primary Frontier (required) as well as Secondary Frontier (optional)



Fermilab Roles in CPM

- Fermilab played a major role in the planning and the content of the meeting
 - Previously covered the Snowmass Advisory Group, Program and Local Committees
- Major Content Contributions
 - 5 FNAL Frontier Conveners organizing the Intro and Planning parallel sessions
 - 32 FNAL Session Co-Conveners (out of ~110 total sessions)
 - 14 FNAL Town Hall Abstracts (out of 67 submissions)
 - 5 FNAL Town Hall Abstracts selected* for session (out of 23 submissions)
 - 39 Speakers (Quantifying total is difficult as many sessions were discussions and panels and not all talks were formally posted)
- Breakdowns by Frontier are less useful, as the PC generally designated 2-4 frontiers per session

* Fermilab author on selected abstract

Fermilab Presentations at CPM

Welcome	Muon Collider MDI
Local Organizing Committee Welcome and Meeting Logistics	Energy Frontier discussion
EF05/06 Letters of Interest on nonperturbative effects in high-precision QCD predictions	Accelerators & beam physics trends
Towards Future Discoveries at the Energy Frontier	Synergy with Muon Collider R&D
Requirements from substructure and jet reconstruction	Measuring very forward hadrons at the LHC
Advanced SRF R&D for Higgs Factory Luminosity (and Energy) Upgrades	Higher Gradient Expectations for SRF for ILC Energy Upgrades
AF5 Plans and Discussion	AF2 Plans and Discussion
SRF for Linear Collider Higgs Factories	AF Grand challenges

Fermilab Presentations at CPM

v-Nucleus scattering brief	ANNIE and the Future of Hybrid Neutrino Detectors
Underground Facility Needs of Quantum Information Science	Computational challenges for neutrino event generators
NF09 Plans and Discussion	DarkQuest and LongQuest at the 120~GeV Fermilab Main Injector
Energy and Power and Time structure goals for Neutrino Frontier programs	Neutrinos and Computing: Preservation, Machine Learning, Uncertainties
Panel discussion of the future of AI/ML	Machine learning for detector simulations
RF6 Light dark matter studies at high intensities	Systematic effects in detector simulations
Cosmic Surveys and Fundamental Physics	Fixed-Target Searches for New Physics with $O(1\text{ GeV})$ Proton Beams at Fermi National Accelerator Laboratory [$+O(10\text{ GeV})$ Lol]
Cosmic Probes of Dark Matter	

Fermilab Presentations at CPM

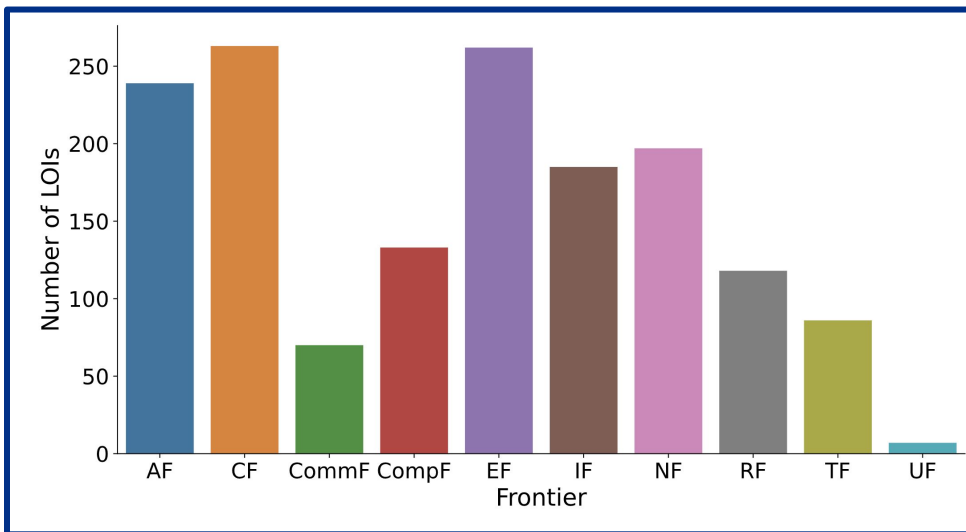
Theory motivation and benchmarks	Operator series and theory errors
Lattice Gauge Theory Panel Discussion	Lattice QCD's role in precision measurements
Report from Instrumentation Frontier	Report from Accelerator Frontier
Closing Remarks	Panel Discussion on Future Accelerator Facilities

Letters of Interest

- Not all contributions to the Snowmass CPM captured by the numbers above because of the meeting time constraints and desire to focus on intersections between frontiers
- The Letters of Interest play a major role in establish the agenda of the frontier and topical workshops, as well as the content of some of the CPM sessions
- Collecting LOIs was a new feature of the Snowmass process for 2020-2021
- In some frontiers, authors were invited to give short summaries of their LOIs
- In other frontiers, the Conveners summarized the contributions in the planning sessions
- Other frontiers have held dedicated frontier workshops to look at LOIs
- *Because the LOIs play a critical role in defining the content for the frontiers a the CPM and CSS, we highlight those numbers as well*

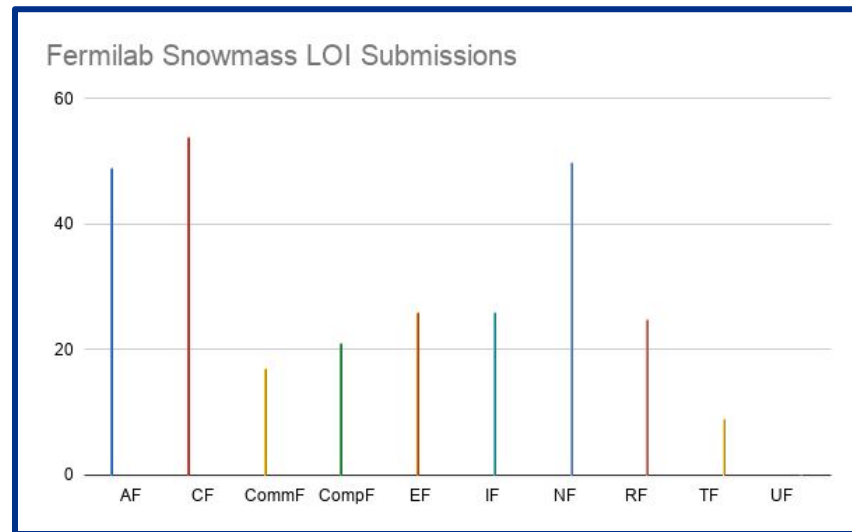
Letters of Interest

- **1574** LOIs submitted by Aug 31st, 2020
- Sorted by primary frontier (defined at submission)



(from Gordon Watts)

- **279** LOIs submitted by FNAL authors (google doc available [here](#))
- 15 additional LOIs propose work at Fermilab but did not include a FNAL co-author
- Breakdown by primary frontier:



AF	CF	CommF	CompF	EF	IF	NF	RF	TF	UF
49	54	17	21	26	26	50	25	9	0

Fermilab Themes and Contributions

- Between CPM session organization, talks and LOIs, FNAL had major contributions in all 10 Frontiers
- The rest of this talk will primarily focus on FNAL contributions to Physics Drivers
 - Energy, Neutrino, Cosmic, Accelerator, Rare/Precision
 - Theory, Instrumentation, Underground and Computing are often intertwined in the themes from the previous frontiers
 - Community Engagement has an active role in this planning process

Themes: Energy

1. Deliver on the currently planned baseline program at the HL-LHC, while pushing the boundaries to maximize the physics (di-Higgs, BSM, dark matter)
2. Continue to support a Higgs Factory (ILC, FCC-ee)
 - a. Many studies are already mature, with the design and sensitivity studies well understood
 - b. Strong interest remains and activity levels are intertwined with global decisions
3. Plan what's next domestically. Notably, a strong community interest has emerged for understanding challenges and opportunities for a Muon Collider
 - a. Emerged as a strong theme in the LOIs
 - b. The EF is developing liaisons with AF, IF, TF in response to this interest
 - c. Upcoming [workshop](#) tomorrow

Themes: Energy

A Long-Lived Particle and Dark Matter Search at the LHC at $z = 80$ - 127 m.
A Very Forward Hadron Spectrometer for the LHC
Are Jets Universal
Collider Phenomenology of the NMSSM Higgs Sector
Dark Matter Searches at Future Colliders: The Unique Reach of the Muon Collider
Electroweak multiplets at the Muon Collider
Electroweak Symmetry non-Restoration and Delayed Electroweak Phase Transitions
Future Energy Frontier Collider Options for the United States
Higgs boson coupling measurements to charm quarks at FCC-ee
Lattice-QCD Determinations of Quark Masses and the Strong Coupling α_s
Letter of Interest: Prospects of Vector boson scattering at future colliders

Long-Lived Neutrinos with CMS high multiplicity shower L1 Trigger Proposal in the Muon System in Run 3 of the LHC

Measurement of Higgs parameters at FCC-ee

Muon collider: A window to new physics

Muon Collider: solidifying the physics case.

Precision measurements of α_s and its running at future colliders

Recent Progress and Next Steps for the MATHUSLA LLP Detector

Recommendations for more precise and robust assessment of experimental and systematic QCD uncertainties

Search for new scalars at FCC-e

Sensitivity reach of scintillation-based detectors for millicharged particles

Sensitivity to Dijet Resonances at Proton-Proton Colliders

The invisible Higgs branching fraction at FCC-ee

Using the phenomenological MSSM to elucidate complementarity of sensitivity to supersymmetry from future colliders, astrophysical and cosmological data, and precision measurements.

xFitter: An Open Source QCD Analysis Framework

Titles of LOI submissions with Fermilab authors

Themes: Neutrino

1. Deliver on the currently planned program that includes LBNF/DUNE and SBN
 - a. Major outcome of 2013 Snowmass/P5 process
 - b. It is critical that this major ongoing commitment is fully realized
2. Develop future detector capabilities to extend physics reach
 - a. Technology improvements: Pixel readout (low-energy atmospheric neutrinos, or 0vBB), xenon doping (0vBB), magnetization (charge discrimination to inform sterile anomalies)
 - b. Dune 4th Module of Opportunity: extend physics reach to very low energies (0vBB)
3. Studying applications of high-intensity fixed-target efforts
 - a. DM + neutrino studies
 - b. Utilize PIP-II + upgrades to booster (1-8GeV) or an accumulator ring (see [workshop](#) next week)
4. Push theory in several dimensions
 - a. BSM connections with neutrino physics including dark sector
 - b. Pushing the subfield of nuclear physics that informs nuclear interactions at HEP detectors

Themes: Neutrino

ANNIE Detector R&D	Letter of Interest ν Reconstruction in the Deep Underground Neutrino τ Experiment
Computing Neutrino Oscillations in Matter Efficiently	Long-Baseline Accelerator Probes for Light Sterile 3 Neutrinos
Connecting QCD to neutrino-nucleus scattering	Low-energy Inelastic Neutrino Cross Section
Dark Sector Studies With Neutrino Beams	Multi-modal Pixels for Noble Element Time Projection Chambers
Directional detectors for CE ν NS and physics beyond the Standard Model	Mutual Benefits derived from the Application of Neutrino Physics to Nuclear Energy & Safeguards
DUNE Near Detector	Neutrino Decay as a Solution to the Short-Baseline Anomalies
DUNE-Beta: Searching for Neutrinoless Double Beta Decay with a Large LArTPC	Neutrino Frontier: White Paper on Neutrino Self-Interactions
Electroweak precision measurements in low energy neutrino experiments	Neutrino Opportunities at the ORNL Second Target Station
Event Generators for Accelerator-Based Neutrino Experiments	Neutrino Physics with Noble Liquid Bubble Chambers
Expected Final Sensitivity of the NOvA Experiment to 3-Flavor Neutrino Oscillations	Neutrino Scattering Measurements on Hydrogen and Deuterium
ICARUS in the Next Decade	Neutrino-induced Shallow- and Deep-Inelastic Scattering
Large Extra-Dimension Searches,	Neutrinos as Probes for Lorentz and CPT Symmetry
Lattice-QCD Calculations Supporting Neutrino-Oscillation Experiments	Neutrinos from stored muons; nuSTORM
Fermilab Lattice and MILC Collaborations	Opportunities and signatures of non-minimal Heavy Neutral Leptons
Letter of Interest Atmospheric ν Appearance in the Deep Underground τ Neutrino Experiment	Physics Opportunities for detection and study of Heavy Neutral Leptons at Accelerator Neutrino Experiments
Letter of Interest Physics Opportunities in ANNIE	

Titles of LOI submissions with Fermilab authors

Neutrino Continued

Physics with Sub-GeV Atmospheric Neutrinos
Reactor neutrino detection experiment using Skipper CCDs
Search for Heavy Sterile Neutrinos Using ^{39}Ar Beta Decays in Large LArTPC Detectors
Search for low mass dark matter at ICARUS detector using NuMI beam
Snowmass2021 - Letter of Interest Precision Neutrino-Nucleus Interaction Physics and BSM Searches at the Short-Baseline Near Detector (SBND) at Fermilab
Snowmass2021 - Letter of Interest Sensitive Tests for Sterile Neutrino Oscillations at the Short-Baseline Neutrino Program at Fermilab
Snowmass2021 - Letter of Interest The NOvA Physics Program through 2025
Sterile Neutrino Searches with Atmospheric Neutrinos
Tau Neutrino Physics

The EMPHATIC Table-Top Spectrometer: Enabling Hadron Scattering and Production Measurements for Improved Beam Simulations
The Exotics and Cosmic Ray Physics Program of NOvA
The future NA61/SHINE program on hadron production
The JSNS2 Experiment
The NOvA Experiment and Exotic Neutrino Oscillations
The NOvA Near Detector Physics Program
The Use of Precision Beam Timing in LBNF/DUNE
Ultralight dark matter and neutrinos
Using Electron Scattering to Constrain Neutrinos

Themes: Cosmic

Cosmic frontier has a diverse program and FNAL is strongly involved at all levels from the topical convener down to subgroups

1. The CPM examined Dark Matter complementarity and reviewed the comprehensive DM measurement program over many orders of magnitude
2. Looking towards silicon technology to push low-mass DM experiments. There is broad support to continue to extend Skipper CCD to develop large-scale silicon effort
3. Interface of axions/Quantum detection/technologies was highlighted and there is a great opportunity for Fermilab to become *the* axion lab
4. Significant effort underway on SPT3, CMB S4
5. Surveys: Leader on DES, DESI, Rubin LSST Ops
 - a. Longer timescale: Snowmass collecting input on a future spectroscopic survey and the relevant R&D efforts
6. Combined probes: Development of tools, analysis techniques, simulations and collaboration policies to facilitate joint analysis

Themes: Cosmic

A deci-Hz Gravitational-Wave Lunar Observatory for Cosmology
A Scintillating n-type GaAs detector for sub-GeV Dark Matter Direct Detection
A simulation program to discover dark matter physics in the sky
Astrophysical signatures of the QCD axion and axion-like particles
Axion Dark Matter eXperiment (ADMX) 2-4 GHz
Compact binaries as probes of dense matter and QCD phase transitions
Cosmic dawn: A probe of dark matter at small scales
Cosmic Neutrino Probes of Fundamental Physics
Cosmic Probes of Dark Matter Interactions: Challenges for Theory and Analysis
Cosmic probes of ultra-light axion dark matter
Cosmology from Multi-Wavelength Observations of Clusters of Galaxies
Cosmology with Millimeter-Wave Line Intensity Mapping
Dark Energy Science with Multimessenger Probes and the Vera Rubin Observatory's Legacy Survey of Space and Time
Dark Matter and Early Universe Physics from Measurements below the Galaxy Formation Threshold
Dark Matter Complementarity

Deep Multi-object Spectroscopy to Enhance Dark Energy Science from LSST
Development of R&D platform for astronomical instrumentation in visible and near-IR
Electromagnetic probes of ultralight primordial black holes
Exploring Beyond-the-Standard-Model Physics with TeV Gamma Rays from Primordial Black Holes
Fundamental physics with gravitational wave detectors
La Silla Schmidt Southern Survey
Light Dark Matter Candidates with MeV gamma-ray signatures
Low-gap charge detection for fundamental physics searches
Measuring H0 in the 2020s
Millimeter-Wave Line Intensity Mapping Facilities
Multi-messenger Probes of Cosmology and Fundamental Physics using Gravitational Waves
Multi-ton scale bubble chambers
New Physics and the Black Hole Mass Gap
Next-generation Spectroscopic Surveys with DESI
Novel dynamical probes of dark matter on small scales
Opening the terahertz axion window
Physical Effects of Nonlocally Coherent Quantum Gravity
Primordial Non-Gaussianity with Millimeter-Wave Line Intensity Mapping

Cosmic Continued

Probing the expansion history of the Universe with Gravitational Waves	The Vera C. Rubin Observatory as a Dark Matter Experiment
Reaching the solar CEv NS floor with noble liquid bubble chambers	The Vera C. Rubin Observatory as a Discovery Facility for Fundamental Physics
Resonant vs. Broadband Axion Dark Matter Searches in the Background-free Limit – an amicus brief for Snowmass CF2 - IF1	Time Delay Cosmography in the 2020s
Rubin/LSST Black Hole Dark Matter Microlensing	Ultralight Bosonic Dark Matter Theory
Search for gravitational waves from ultralight boson clouds around black holes	Understanding the Galactic Center Gamma-Ray Excess
Searching for complex Dark Sectors with KIDs and CCDs	UP-conversion Loop Oscillator Axion Detectors (UPLOAD)
Snowmass2021 Letter of Interest: Long-baseline Atomic Sensors for Fundamental Physics	WIMP Dark Matter Candidates with MeV gamma-ray signatures
Status and plans for Oscura: A Multi-kilogram Skipper-CCD Array for Direct-Detection of Dark Matter	
Strong Lensing Probes of Dark Matter	
Synergies between Millimeter-Wave Line Intensity Mapping with Radio, Optical and Microwave Observations	
Testing the Nature of Dark Matter with Extremely Large Telescopes	
The Maunakea Spectroscopic Explorer	
The Rubin/LSST Dark Energy Science Collaboration: Operations during the LSST Survey	
The Stochastic Gravitational Wave Background as a Probe of New Physics from the Early Universe	

Titles of LOI submissions with Fermilab authors

Themes: Rare Processes

1. Deliver on existing program (Mu2e, g-2) and maximize the physics output
 - a. Another product of the previous P5 process, and we are reiterating that Mu2e will run during this next P5 period
2. Utilize ongoing accelerator upgrade to extend physics reach in related areas
 - a. Mu2e-II extends reach and probes the nature of new physics if discovery at Mu2e
 - b. REDTOP is an eta factory with a broad physics program to search for BSM physics in flavor-conserving processes
 - c. LDMX, Darkquest/Longquest, M³ - Dark Matter Searches with High Intensity Beams at a variety facilities
3. Significant suite of proposals submitted to unite the CLFV community and make FNAL the leader in multiple CLFV channels
 - a. Building collaborations with world experts in CLFV
 - b. Potential for 600+ person program following the planned Mu2e effort
 - c. Utilizing existing expertise to push for relevant AF design, which includes 4 complementary AF LOI submissions

Themes: Rare Processes

$\Delta B = 2$: A State of the Field, and Looking Forward
A New Charged Lepton Flavor Violation Program at Fermilab (ENIGMA: nExt geNeRation experiments with high intensity Muon beams)
A Phase Rotated Intense Source of Muons (PRISM) for a $\mu \rightarrow e$ Conversion Experiment
Accelerator Probes of Millicharged Particles and Dark Matter
Atomic/nuclear clocks and precision spectroscopy measurements for dark matter and dark sector searches
Considerations for a Mu2e-II Production Target
DarkQuest and LongQuest at the 120 GeV Fermilab Main Injector
Fixed-Target Searches for New Physics with O(1 GeV) Proton Beams at Fermi National Accelerator Laboratory
Fixed-Target Searches for New Physics with O(10 GeV) Proton Beams at Fermi National Accelerator Laboratory
FNAL Booster Storage Ring
Free Neutron-antineutron Transformation Searches at the European Spallation Source's Large Beamport
High precision determinations of $ V_{xb} $ from a close theory-experiment collaboration
Letter of Interest for an Upgraded Low-Energy Muon Facility at Fermilab
Letter of Interest for the Muon Missing Momentum experiment

Mu2e Letter of Interest for Snowmass 2021
Mu2e-II Letter of Interest for Snowmass 2021
Mu2e-II: a 2-level TDAQ system based on FPGA pre-filtering
Mu2e-II: a trigger-less TDAQ system based on software trigger
Mu2e-II: TDAQ based on GPU co-processor
Potential storage ring and Muon Campus experiments Letter of Interest for Snowmass 2021
Precise Lattice QCD calculations of kaon and pion decay parameters and first-row CKM unitarity tests Snowmass
Searching for $\mu \rightarrow e +$ Conversion at Upcoming Experiments and the Process of Radiative Muon Capture
The quest for explaining the top-row CKM unitarity deficit
The REDTOP experiment: an η/η' factory
US Participation in Current & Future Rare Kaon Decay Experiments

Titles of LOI submissions with Fermilab authors

Themes: Accelerator

1. Deliver on existing program with proton accelerators for neutrino program
 - a. Deliver High-intensity beams for LBNF
 - b. Develop targets for High-intensity beams
 - c. Push for Booster Upgrade to continue leading the field
2. Significant accelerator interest in colliders, lots of interactions with AF, EF
 - a. FNAL has a lot of expertise and would be a major player in any e^+/e^- collider
 - b. Muon collider - extend energy reach by factor 7
 - c. Future technologies (e.g. plasma accelerator)
3. Push the envelope of accelerator technology (Magnets, cavities, facilities, SRF, targets, sources, etc...)
4. Continued advocacy for general accelerator science and AF education
 - a. IOTA/FAST as leading facility for long term R&D
 - b. Accelerators for Rare processes (see previous talk)
 - c. Accelerator education infrastructure

Themes: Accelerator

20 T Hybrid Magnets
30 T BSCCO solenoids are now in view
Accelerator and Beam Physics: Grand Challenges and Research Opportunities
Advanced Beam Cooling LoI to Beam Physics and Accelerator Education
Advanced modelling for High Power Targetry
An International Exchange Framework for Research in Beam Physics and Accelerator Technology
At Risk: University-based Accelerator Science and Education
Beamdump Experiments Driven by a Plasma Wakefield Accelerator
Bunch Compressor for the PIP-II Linac
Compact Superconducting RF Accelerators
Electron Lenses for Colliders and Intense Proton Beams
FNAL Booster Storage Ring
Future Energy Frontier Collider Options for the United States
GARD Beam Test Facilities
High Efficiency, Low Cost, RF Sources for Accelerators and Colliders
High field superconducting accelerator magnet technologies based on Bi-2212 high- temperature superconductor for future accelerator facilities

Ion Coulomb Crystals in Storage Rings for Quantum Information Science
IOTA-FAST A Leading US Facility for Beam Physics and Accelerator Technology R&D: Long-Term Research Opportunities
Irradiation facilities and irradiation methods for High Power Targetry
Issues and Mitigations for Advanced Muon Ionization Cooling
Key Directions for Research and Development of Superconducting Radiofrequency (SRF) Cavities
Letter of Interest in a Linac-based 8 GeV Accelerator for Booster Replacement and other Applications
Letter of Interest: Beam Delivery for Mu2e-II in the PIP-II Era
Mitigation of Emittance Dilution Due to Wakefields in Accelerator Cavities Using Advanced Diagnostics with Machine Learning Techniques
Muon Collider: Machine Detector Interface Studies
Nanostructure Accelerators Novel concept and path to its realization
Nb3Sn Superconducting Radiofrequency Cavities
Next Generation SRF accelerators based on Nb3Sn
Novel materials to improve High Power Target reliability
Optimizing the FCC-hh Hadron Collider
Perspectives on International Superconducting Linear Colliders (ILC) to the Next Century Part A: High Luminosity Higgs Factory and Top Factory
Perspectives on International Superconducting Linear Colliders (ILC) to the Next Century Part B: ILC Energy Upgrades to 3 TeV and Beyond
Post-Irradiation Examination (PIE) for High Power Targetry at Fermilab

Titles of LOI submissions with Fermilab authors

Accelerator Frontier Continued

R&D for MW Pion Production Targets for Next Generation Long Baseline Neutrino Facilities

R&D in Nb₃Sn and Iron-based Superconductors for High Field Magnets

R&D on Extreme Six-Dimensional Cooling for a Muon Beam

R&D on High Power Fundamental Power Couplers for Superconducting Cavities

R&D on High-Power Target System for future HEP experiments

Research and Development to Advance Technology of Strong Cooling of High Energy Hadron Beams

Solving Critical Problems of the Energy Frontier Muon Collider: Optics, Magnets and their Protection, Detector Backgrounds and Neutrino Hazard

Solving Critical Problems of the Muon Collider Higgs Factory: Optics, Magnets and their Protection, and Detector Backgrounds

Strategy for HEP Accelerator Workforce Training in Coordination with BES, NP, and Industry

Stress Management Technology for High-field Accelerator Magnets based on Stress/strain Sensitive Superconductors

Superconducting Free Electron Laser Undulators for gamma gamma Colliders

Superconducting Technologies and Materials for Muon Collider Magnets

The Center for Bright Beams as a model for accelerator research and education

The Need for Research into Early Conceptual Integration and Optimization, and Maturity Evaluation of Future Accelerators

Ultimate Acceleration in Crystals and Nanostructures

Ultra-thin A15 Superconducting Wires for Future High Field Accelerators

University Research and Training of Accelerator Scientists and Engineers

US Particle Accelerator School Long Term Needs to Support Training Accelerator Scientists and Engineers

Versatile Multi-MW Proton Facility with Synchrotron Upgrade of Fermilab Proton Complex

Instrumentation Frontier

- Major synergies with EF, IF, AF, NF
- Fermilab a key player in pushing many technologies and facilities

3D Integration of Sensors and Electronics	Muon Collider experiment: requirements for new detector R&D and reconstruction tools
Charge-Coupled Device Technology Development for Future Dark Energy and Dark Matter Studies	New Test Beam Facility at Fermilab
Electron multiplication in liquid argon TPC detectors for low energy rare event physics	Non-destructive readout in CMOS technology.
Enabling precision calibration of massively multiplexed spectroscopic surveys	On-chip spectrometers for long wavelength photon detection
Enabling the next generation of bubble-chamber experiments for dark matter and neutrino physics	Real-time adaptive deep-learning with embedded systems for discovery science
High granularity, high dynamic range Calorimeter readout electronics	Scintillator Extrusions for Mega-detectors: MATHUSLA
High Intensity Proton Irradiation Facility	Skipper CCDs for Cosmic Surveys of Dark Energy and Dark Matter
Homogeneous Hadron Calorimetry for Future Higgs Factory Experiment	Snowmass LOI: Precision Calibration of Large LArTPC Detectors
Identification of TeV hadrons: Transition Radiation Detectors	The Matter wave Atomic Gradiometer Interferometric Sensor (MAGIS-100) Experiment
Injection molded scintillator for future high granularity experiments – DUNE 3DST	The Microwave SQUID Multiplexer for Cosmology and Cryogenic Particle Detection
Instrumentation Frontier Magnetizing the Liquid Argon TPC	Towards Directional Nuclear Recoil Detectors: Tracking of Nuclear Recoils in Gas Argon TPCs
Kinetic Inductance Detectors for long-wavelength photon detection	Towards High Volume Production of LAPPDs Using Air-Transfer Process
Magnetizing the Liquid Argon TPC	Developing Small-Pitch Optical Fiber Positioners for Massively Parallel Spectroscopy
Mechanical sensors as particle detectors: Snowmass LO	

Titles of LOI submissions with Fermilab authors

Computing Frontier

- CPM focused on logistics and introducing LOIs to the CompF community
- Focus emerging on Machine Learning, Quantum systems, Simulations and Facilities Evolution

Analysis Facilities

Aspiration for Open Science in Accelerator & Beam Physics Modeling

Cloud Computing

CosmoSIS for the Next Decade

Cycle and symbiosis: AI and Cosmology intersect to produce new knowledge and tools

Data Preservation at MINERvA

Develop/integrate data standards & start-to-end workflows for Accelerator Physics

Differentiable Programming in High-Energy Physics

Graph Data Structures and Graph Neural Networks for High Energy Physics

HEP Computing Challenges

HEP reconstruction at HPC centers: an approach for efficient utilization of resources

High Energy Physics Detector and Beamline Simulations in the 21st Century

HPC Complementary Computing Facility Topical Group(s): ☒ (CompF04)
Storage and processing resource access

Neutrino Event Generators

New Computing Model for Experiments Utilizing Large Scale Liquid Argon TPCs

Numerical Lattice Gauge Theory

Numerical Modeling for Superconducting Accelerator Magnets

Open Quantum Systems Simulation for HEP

Simulations for HEP with SQMS Quantum Hardware Thematic Areas

Software and Statistics for Discovery in Cosmic Frontiers Experiments

Storage Research and Development at Large HEP Computing Sites

Titles of LOI submissions with Fermilab authors

Theory Frontier

- Many papers submitted to the related frontier, but several submitted to TF as the primary frontier

Warped Extra-Dimensional Geometry and Localized Gravity
Algorithms and Software in Support of Computational HEP and NP at the Exascale and Beyond
Benchmarking Quantum Platforms with High Energy Physics
Exotic light dark matter signals at existing experiments
Lattice-QCD studies of inclusive B -meson decays Snowmass Topical Groups:
Microscopic approaches to neutrino-nucleus interactions
Multi-loop Amplitudes for Colliders
Precision Lattice QCD in Support of BSM Searches
Theory developments for low-threshold dark matter direct detection

Community Engagement Frontier

- Improving culture and equity
- Building stronger collaborations
- Interactions between scientists and non-scientists
- Tech transfer opportunities

Letter of Interest Science / Society: considering new paradigms of planning for public engagement and communication

Catalyzing Societal Impact – IARC at Fermilab Snowmass 2

Collaboration between industry and the HEP community

Community Support for Enforcing Collaboration Codes of Conduct

Culture change is necessary, and it requires strategic planning

Envision Just Scientific Collaborations

Ethical implications for computational research and the roles of scientists

Expanding Fermilab's international outreach through European Networks

Extending I-CORPS to HEP

Extending Other Transaction Authority

Extending OTT FedTech to HEP

Increasing Awareness of and Participation in the Visiting Faculty Program

Snowmass Early Career Longterm Organization

Snowmass2021 - Letter of Interest Understanding the process is critical for agency, intervention, and influence

Towards Equitable Hiring in High Energy Physics

Training in the U.S. of Italian Science Students

Training a Diverse HEP Workforce in Small Neutrino Experiments

Summary

- CPM was a major step towards the 2021 Snowmass CSS
- Fermilab made major contributions to the planning, organization and content of the meeting through talks and LOIs
 - These events have stimulated new discussions between scientists at the laboratory
 - All-Scientist retreat with ~150 participants held last Friday to highlight some of the newer initiatives and foster cross-cutting interest and participation
 - SAC plans on holding a series of such meetings in the new year
- Specific Themes are emerging in multiple frontiers
 - Deliver the ambitious program that we have committed to
 - Extend the physics reach through detector and instrumentation upgrades
 - Advance new technologies to probe new energy ranges
 - Work closely with the theory frontier and develop the physics case to build future facilities that are critical to achieving the goals of the community
 - Develop the community, computing, and instrumentation infrastructure needed to achieve these goals

Backup

Wednesday parallels

← → ↺ ⚠ Not Secure zgecse.web.cern.ch/zgecse/SessionTimeline.html																									
		Monday 05/10										Tuesday 06/10		Wednesday 07/10			Thursday 08/10								
Time: (CDT)		11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00			
Join Webinar		Plenary: Community Engagement Across the Frontiers (#cpm_plenary_engagement_across_frontiers)																							
Join Zoom 1							Break and chat			26. Energy Frontier discovery machines						Break and Chat		201. EF Planning (#cpm_ef_planning)							
Join Zoom 2							Break 2			110. Baryon and Lepton Number Violating processes				Zoom 2 Break and Chat			202. NF Planning								
Join Zoom 3							150. Dark matter complementarity - #cpm_topic_150			75. Cosmic Probes of Dark Matter Physics - #cpm_topic_75						Zoom 3 Break and Chat		203. CF Planning							
Join Zoom 4							190. Discussion of accelerator project implementation			44. New accelerator concepts for high intensity muon beams				Zoom 4 Break and Chat			204. AF Planning								
Join Zoom 5							Break 5			41. Anomalies in Flavor Physics				Zoom 5 Break and Chat			205. RF Planning: 205. RF Planning								
Join Zoom 6							151. Dark Energy Strategy			Zoom 6 Break and Chat			105. The Reach of Formal Theory			Zoom 6 Break and Chat		206. TF Planning							
Join Zoom 7							Break 7			115. Neutrinos, dark matter, and underground facilities				Zoom 7 Break and Chat			207. UF Planning								
Join Zoom 8							Break 8									57. Connection with industry			208. CEF Planning						
Join Zoom 9							Break 9			119. HEP and Accelerator Workforce, Careers, and Training						Zoom 9 Break and Chat		209. IF Planning							
Join Zoom 10							Break 10			84. Computing Requirements & Opportunities in Theory				Zoom 10 Break and Chat		210. CompF Planning		Zoom 10 Break and Chat		210. CompF Planning					
Join Zoom 11							Break 11			28. Theory Challenges in Precision Measurements						Zoom 11 Break and Chat									
Join Zoom 12							Break 12			99. Advances in Event Generation and Detector Simulation						Zoom 12 Break and Chat									
Join Zoom 13							Break 13			148. Future gravitational wave facilities				144. New facilities for dark energy											
Join Zoom 14							Break 14			137. High and ultrahigh energy neutrino experiments - #cpm_session_137				138. Synergy of astro-particle physics and collider physics											
Join Zoom 15																									
Join Zoom 16																									
Join Zoom 17																									
Join Zoom 18																									
Join Zoom 19							Break 19			184. Sources and targets for future accelerators				185. High power proton beams for rare searches		Zoom 19 Break and Chat									
Join Zoom 20							Break 20			186. High field (Schwinger limit) physics with intense		187. Machine Detector Interface with plasma lenses and plasma		188. Plasma Acceleration for fixed target experiments		Zoom 20 Break and Chat									
Join Zoom 21							Zoom 21 Break			189. AF7 magnets organization with contributors				Zoom 21 Break and Chat											

All Frontier Conveners

From Young-Kee Kim

- 5 FNAL staff
- 9 FNAL users

Frontier Conveners

Energy
Frontier



Meenakshi Narain
(Brown U)



Laura Reina
(FSU)



Alessandro Tricoli
(BNL)

Accelerator
Frontier



Steve Gourlay
(LBNL)



Tor Raubenheimer
(SLAC)



Vladimir Shiltsev
(FNAL)

Frontiers in
Neutrinos



Patrick Huber
(Virginia Tech)



Kate Scholberg
(Duke U.)



Elizabeth Worcester
(BNL)

Instrumentation
Frontier



Phil Barbeau
(Duke)



Petra Merkel
(FNAL)



Jinlong Zhang
(ANL)

Frontiers
in Rare &
Precision



Marina Artuso
(Syracuse U.)



Alexey Petrov
(Wayne State U.)



Bob Bernstein
(FNAL)

Computational
Frontier



Steven Gottlieb
(Indiana U.)



Ben Nachman
(LBNL)



Oliver Gutsche
(FNAL)

Cosmic
Frontier



Aaron Chou
(Fermilab)

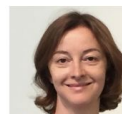


Marcelle Soares-Santos
(U. Michigan)



Tim Tait
(UC Irvine)

Underground
Facilities and
Infrastructure
Frontier



Laura Baudis
(U. Zurich)



Jeter Hall
(SNOLAB)



Kevin Lesko
(LBNL)



John Orrell
(PNNL)

Theory
Frontier



Nathaniel Craig
(UCSB)



Csaba Csaki
(Cornell)



Aida El-Khadra
(UIUC)

Community
Engagement
Frontier



Kétévi Assamagan
(BNL)



Breese Quinn
(Mississippi)